

**WHAT IS CLAIMED IS:**

1. A vapor delivery system for delivering a controlled flow of vapor sublimated from a solid material (29; 140; 200) to a vacuum chamber (130; 258; 260), comprising the combination of a heated vaporizer (28; 145; 205; 400) for the solid material operable at sub atmospheric pressure and a vapor delivery passage (37; 237) from the vaporizer to the vacuum chamber, the vapor delivery passage including a throttle valve (100; 100'; 235; 430) followed by a vapor conduit (32; 150; 228), a pressure gauge (60; 240; 450) that is responsive to sub atmospheric pressure being located between the throttle valve and the vapor conduit, surfaces of the vapor delivery passage that are exposed to the sublimed vapor, including such surfaces of the throttle valve, the pressure gauge and the vapor conduit, being adapted to be held at temperature above the condensation temperature of the solid material, and a closed-loop control system (60; 120; 240, 250, 245; PID2) incorporating the pressure gauge being constructed to vary the conductance of the throttle valve to control the sub atmospheric pressure of the vapor downstream of the throttle valve in response to the output of the pressure gauge, flow of vapor to the vacuum chamber thereby being determined by pressure of the vapor in the region of the passage between the throttling valve and the vapor conduit (32; 150; 228).
2. The vapor delivery system of claim 1 including a temperature controlling system (35) adapted to hold the temperatures of the surfaces of the delivery passage (37; 237) above the temperature of the vaporizer.
3. The vapor delivery system of claim 2 having multiple stages of the vapor delivery passage adapted to be held at progressively higher temperatures, the more distant the stages are from the vaporizer.
4. The system of claim 1, 2 or 3 wherein the vapor flow rate is adapted to be determined by both a control system (35; 225, 215, 248; PID1) for the temperature of the vaporizer and said control system (60, 120; 240; 250; 245; PID2) for the conductance of the throttle valve.

5. The system of any of the foregoing claims wherein the temperature of the vaporizer is determined by closed-loop control to a set-point temperature.
6. The vapor delivery system of any of the foregoing claims in which the maximum N<sub>2</sub> conductance of the throttle valve is at least 1 liter per second.
7. The vapor delivery system of any of the foregoing claims in which the pressure drop across the throttle valve when the valve is operationally fully open is less than 100mTorr.
8. The vapor delivery system of any of the foregoing claims in which the maximum conductance of the throttle valve (100; 100'; 235; 430) is at least 5 times the conductance of the vapor conduit (32; 150; 228).
9. The vapor delivery system of any of the foregoing claims in which the maximum conductance of the throttle valve is at least 10 times the conductance of the vapor conduit.
10. The vapor delivery system of any of the foregoing claims in which said throttle valve is a variable-position gate valve.
11. The vapor delivery system of any of the foregoing claims in which said throttle valve is of the butterfly type.
12. The vaporizer delivery system of any of the foregoing claims constructed to operate with a rechargeable fixed charge of solid material (29; 140; 200) which is progressively consumed in a manner to reduce the vapor-emitting area of the solid material, and constructed, in response to a decrease in pressure beyond the throttle valve (100; 100'; 235; 430), to reset the position of the throttle valve to recover the desired flow, and also from time to time, as the throttle valve nears its maximum useful conductance, to elevate the temperature of the vaporizer (28; 145; 205; 400) to raise the pressure in the vaporizer and enable the throttle valve to operate within its preferred conductance dynamic range.
13. The vaporizer delivery system of claim 12 in combination with a throttle valve-based sensing and control system capable of providing a vaporizer set-point temperature value

to a regulator of a vaporizer heater that is capable of maintaining the vaporizer temperature at the set-point, the sensing and control system storing at least one predetermined valve displacement value representing a desired upper conductance limit for the throttle valve, the sensing and control system constructed to monitor the position of the throttle valve, and upon detecting the valve nearing or reaching that displacement value, the sensing and controller system constructed to raise the set-point temperature value to the regulator heater (as by input 246) to cause increased vapor generation and vapor pressure upstream of the throttle valve, thereby to enable the closed loop control of the throttle valve to cause the valve to return to a substantially lower conductance position.

14. The vaporizer delivery system of claim 13 including a reference table of predetermined increments of temperature rise suitable for operation, and the sensing and control system effective, upon detecting the valve nearing or reaching said displacement value, to cause the vaporizer temperature set-point to be incremented to the next step in the reference table.

15. The vapor delivery system of any of the foregoing claims constructed and arranged to deliver ionizable vapor to an ion source.

16. The vapor delivery system of claim 15 constructed and arranged to deliver ionizable vapor to the ion source of an ion implanter.

17. The vapor delivery system of any of the foregoing claims constructed and arranged to deliver vapor to a work piece processing vacuum chamber.

18. The vapor delivery system of claim 17 constructed and arranged to deliver ionizable vapor to a process chamber for dosing semiconductors.

19. The vapor delivery system of any of the foregoing claims constructed to convey its vapor to a high vacuum, the system constructed to respond to decrease in sub atmospheric pressure downstream of the throttle valve (100; 100'; 235; 430) to increase the temperature of the vaporizer (28; 145; 205; 400).

20. The vapor delivery system of any of the foregoing claims in which the control system for the throttle valve includes a servo loop which adjusts the position of the throttle valve (100; 100'; 235; 430) in response to the output signal of the pressure gauge (60; 240; 450) to maintain said downstream vapor pressure at said gauge to a set-point value.
21. The vapor delivery system of any of the foregoing claims in which the vaporizer is constructed to contain and evaporate decaborane,  $B_{10}H_{14}$ .
22. The vapor delivery system of any of the foregoing claims 1-20 in which the vaporizer is constructed to contain and evaporate octadecaborane,  $B_{18}H_{22}$ .
23. The vapor delivery system of any of the foregoing claims 1-20 in which the vaporizer is constructed to contain and evaporate indium trichloride,  $InCl_3$ .
24. The vapor delivery system of any of the foregoing claims 1-20 in which the vaporizer is constructed to contain and evaporate trimethyl indium,  $In(CH_3)_3$ .
25. The vapor delivery system of any of the foregoing claims 1-20 in which the vaporizer is constructed to contain and evaporate triethyl antimony,  $Sb(C_2H_5)_3$ .
26. A method of delivering to a vacuum chamber a controlled flow of vapor sublimated from a solid material conducted by use of the vapor delivery system of any of the foregoing claims.
27. A method of producing an ion beam in a vacuum chamber conducted by use of the vapor delivery system of claim 15 or 16 to deliver a controlled ionizable flow of vapor sublimated from a solid material to an ionization chamber.